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EXPLORING THE INTERNALIZATION RATIONALE FOR INTERNATIONAL INVESTMENT: WHOLLY OWNED SUBSIDIARY VERSUS TECHNOLOGY LICENSING IN THE WORLWIDE CHEMICAL INDUSTRY[1]

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Abstract

Globalization has underlined the need for firms to exploit technological capabilities on a global scale. This study attempts to make a comprehensive investigation of various factors influencing the choice between wholly owned subsidiary and technology licensing as a strategy for expansion abroad. To underpin our main research questions, we rely on different theoretical contributions which have variously emphasized the importance of cultural distance, learning, nature of technology and competition. Specifically, this paper addresses the following issues: -Does cultural distance influence the choice between wholly owned subsidiary and technology licensing? - Do firms learn from previous business practices in foreign countries? - How does the presence of other sources of technological competencies affect the entry modal choice?. We test our hypotheses using a novel and extremely comprehensive database on worldwide plant level investments in the chemical industry during the 1980s. After controlling, to our best, for the nature of the technology and for firm - and country- specific heterogeneity, we find that cultural distance and multiple sources of technological competencies favor the use of licensing as a strategy for expanding abroad, whereas, prior experience favor the choice of wholly owned subsidiary.

Keywords: Technology licensing, wholly owned subsidiary, chemical industry.

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INTRODUCTION

As the world globalizes, the imperatives firms face to exploit technological competencies on a global scale, rather than national, increase as well. Indeed, during the last decades firms have increasingly committed themselves to global markets. This has coincided with a surge in the worldwide flows of foreign direct investment which have grown at the annual rate of 12% between 1991 and 1996, reaching a global stock of $3200 billion in the year 1996 (World Bank, 1997). Similarly, cross-border licensing agreements have been a source of large profits in many industries (see for instance, Parr and Sullivan, 1996) and other forms of international expansion have become widespread in recent years.

Both wholly owned subsidiaries and licensing contracts, along with exports and joint ventures are potential channels for the exploitation of technological competencies across national boundaries. The choice, however, is a critical determinant of the likely success of the foreign project (Root, 1987; Davidson, 1982; Killing, 1982). Understanding the factors that condition a firm's choice among the different alternatives is an important challenge in the field of international business studies. We follow in this tradition and focus specifically on whether technological competencies are exploited in foreign markets licensing agreements or wholly owned subsidiaries. These two alternatives lie at the extremes of a continuum of governance structures ranging from a hierarchy to a market mechanism (e.g., Williamson, 1991). In the last part of the paper we extend our analysis to include joint ventures with local firms, an intermediate governance structure.

Despite the considerable body of theoretical work both by business theorists and economists (see literature review in section 2), there are relatively few empirical studies that address this topic is a comprehensive way. (Contractor and Kundu, 1998, is a recent exception.) Typically, the empirical research has focused on the internationalization strategies of a restricted sample of firms, most of the times of the same nationality, and addressed separately the different implications emerging from the theory. One obvious justification for this lack of comprehensive empirical studies is the difficulty in collecting data. Our research uses data on investment projects in the chemical industry worldwide. This is a new and rich database that has not been explored in previous studies of entry modal choice. Although limited to one sector, it has the virtue of being comprehensive, covering the universe of projects undertaken all over the world for a large number of years. This allows us to test simultaneously different theoretical contributions on the entry modal choice and control for many sources of heterogeneity. In addition, the chemical industry constitutes a natural test-bed for analyzing these issues because it is both a technology-based industry and truly global industry.[1]

We use our data to address the following research questions. First, does cultural distance influence the choice between wholly owned subsidiary and technology licensing? Contractor and Kundu (1998), using data on the worldwide hotel industry, have found no effect of cultural distance. However, other studies (e.g., Kogut and Singh, 1988; Barkema, Bell and Pennings, 1996; Hannart and Larimo, 1998), although focusing on different entry modes, report that cultural barriers are important in shaping international expansion strategies.

Second, do firms learn from previous business practices in foreign countries? The literature suggests that multinational firms through past experience are able to reduce entry barriers, both in terms of cultural distance (Hofstede, 1991), knowledge of business routines abroad (Ermanilli and Rao, 1993) and bargaining position vis-à-vis local governments (Lecraw, 1984). This study tests whether this learning contributes substantially in reducing entry costs and therefore in making wholly owned subsidiary more likely. Contractor and Kundu (1998) find that equity-based modes are preferred by companies with considerable experience and existing geographic reach. However, Benito and Gripsrud (1992) reject the hypothesis that current levels of direct investment in culturally remote countries will increase with previous levels of foreign direct investment. We also test if some forms of entry provide to the investor more experience than others.

Third, how does the presence of other sources of technological competencies influence the entry modal choice? Although even simple strategy theory implies that a firm's strategy cannot be worked out in isolation, studies of entry modes in foreign markets have largely ignored this basic point. However, it is likely that when the technological competencies the firm possesses are not unique, i.e., when there exists a market for technology (Arora, Fosfuri and Gambardella, 1999), the strategic imperatives conditioning the choice between wholly owned subsidiary and licensing differ from the imperatives when the firm possesses unique and "difficult to replicate" technological capabilities. Further, since the presence of alternative sources of technological competencies might simply be a proxy for more fundamental attributes of the technology (Kogut and Zander, 1993; Arora and Gambardella, 1994), in our empirical analysis we shall control for characteristics of the technology such as codifiability and complexity.

BACKGROUND

About forty years ago, Hymer (1960), in his doctoral dissertation, wondered why multinational firms existed at all in face of presumed penalties for operating across national and cultural boundaries. There are obvious added costs of doing business in another country, including communications and transport costs, higher costs of stationing personnel abroad, barriers due to language, customs, and being outside the local business and government network. The logic put forward by Hymer still remains persuasive: the multinational must bring some inherent advantages that potentially constitute an important edge over local competitors. The principal belief of the theory of foreign direct investment is that the primary advantage that a firm brings to foreign markets is its possession of superior knowledge, whether it be the knowledge underlying technology, production, marketing or other activities. Initially, the research was focused on understanding why the firm needed to locate in the foreign markets vis-à-vis producing at home and supplying the foreign locations through exports. Indeed, much of the early literature on the entry modal choice primarily addressed the decision between exporting and foreign direct investment (Caves, 1971; Rugman, 1981; Root, 1987).

Although, "locational" considerations, such as tariffs, transport costs or comparative advantages, could mandate that the firm not concentrate all operations in one country and export to others, it still remained to explain why foreign direct investment should be preferred to the arm's length use of markets. The "eclectic theory" developed by Dunning (1981) and formalized by Buckley and Casson (1981), pointed to "internalization" advantages (see for a generalization, Buckley and Casson, 1998). Applying the insights of the transaction cost theory (Williamson, 1991), this approach suggests that, absent significant contracting hazards, the 'default' low-cost governance mechanism is a simple contract. Put it differently, in a world without transaction costs, an arm's length contract such as licensing would be the most direct way to capture the profit from the intellectual asset (such as a process or an idea) a firm holds. The licensing fees ought to match the profits the firm could make by producing locally. However, writing and executing a reliable contract for the use of technology requires adequate specification of property rights, monitoring and enforcement of contractual terms – any of which may be problematic (Contractor, 1981; Teece, 1988). In turn, this might also increase the potential for leakage of valuable intellectual property (Fosfuri, 1999). Caves, Crookell and Killing (1983) find that, due to imperfections in the licensing market, licensors capture only about a third of the rents from the innovation.

An interesting twist to this approach is provided by Kogut and Zander (1992) and Arora and Gambardella (1994). They point out that the reason why one may not see market-based transactions in technologies cannot ascribed solely to the classical market failure argument. There are cognitive aspects to be taken into account. Specifically the fact that knowledge or technologies are embedded into organizational routines provides a serious constraint to the choice of transferring them to other agents. In a related work, Kogut and Zander (1993) argue that "multinational corporations arise not out of the failure of markets for buying and selling knowledge, but out of its superior efficiency as an organizational vehicle by which to transfer this knowledge across borders". Although theoretically different, their approach leads to conclusions and implications that are empirically equivalent to the ones generated by the transaction cost theory. Indeed, they posit that the nature of the knowledge, or technology, is the main determinant of the choice of the mode of international expansion. If the knowledge is tacit, complex and difficult to teach then – they argue – intra-firm transfers of knowledge are easier than inter-firm transfers. However, it is exactly when the knowledge is tacit and complex that contracting upon it becomes more problematic and transaction costs are the largest (Arrow, 1962; Teece, 1977; Williamson, 1991).

A second piece of theory that we shall appeal to in developing our hypotheses is based on the behavioral theory of the firm. This approach adds to the picture a dynamic component. The idea is that firms stay close to their past practices and routines (Cyert and March, 1963) and therefore the process of internationalization can only be gradual and sequential. Firms operating internationally face a large amount of uncertainty, to which they answer with a stage by stage strategy. Elaborating on this approach, the Uppsala school maintains that in this slow process of sequential steps the firm oriented towards globalization learns habits, preferences, and the market structure of the target countries (Johanson and Vahlne, 1977). This knowledge is a critical resource since the knowledge needed to operate in any country cannot easily be acquired. The more the firm learns about the local conditions, the cheaper is the subsequent investment by the firm in that economy. A related aspect of the Uppsala school is that a firm moves to distant countries only after having established a presence in more proximate countries. Then the firm will gradually penetrate countries at a greater "psychic" distance, which is often associated with a greater geographic distance.

Finally, a more recent approach is provided by the "syncretic" theory of the entry modal choice. This approach, developed by Hill, Hwang and Kim (1990) and Contractor (1990), focuses on the different level of control, resource commitment and dissemination risk involved respectively in licensing and wholly owned subsidiaries (joint ventures are classified as an intermediate choice between these two extremes). Specifically, in the case of licensing, the control is transferred to the licensee in exchange for lump-sum payments and royalties, while in the case of wholly owned subsidiary, the firm retains the ultimate control of the most important strategic decisions concerning the foreign operation. As for the level of resource commitment, licensing requires limited dedicated assets for the licensor, apart from personnel involved in training licensees and subsequent monitoring, while in a wholly owned subsidiary the firm bears all the costs of opening up the affiliate and serving the foreign market. Finally, licensing implies a much larger risk that firm-specific advantages in know-how will be disseminated. It is not unusual for a former licensee to evolve into an aggressive competitor. This suggests that both strategic variables, environmental variables and transaction-specific variables can play a role in shaping the decision between licensing and wholly owned subsidiary. Consequently, in our empirical analysis we shall control for firm-, country- and technology-specific sources of variation. To the best of our knowledge, the only empirical study attempting to test the "syncretic" theory is Contractor and Kundu (1998).

HYPOTHESES

To underpin our research questions, we rely on the different theoretical contributions briefly reviewed in the previous section which have variously emphasized the importance of cultural distance, learning, nature of technology and competition.

Cultural Distance

The seminal work by Hofstede (1980) has shown the importance of cultural differences for the way business practices are conducted. Globalized firms need to know how to run businesses in the target country to exploit their technological advantages and competencies at full effect. The further is the distance in values, customs and behaviors between their home country and the host country, the more difficult is for foreign investors to successfully proceed in their process of internationalization. For instance, Hennart and Larimo (1998) report that Japanese multinationals have had much serious problems than their Finnish counterparts in dealing with the role of women in business in their US-based subsidiaries.

But as clearly stated by Hofstede (1991) the importance of cultural distance changes according to the way international businesses are organized. A wholly owned subsidiary requires the coordination of the foreign affiliate through the expatriate managers, who have to live and work following the foreign customs. This is precisely the same argument that Hymer raised (see section above) while wondering why multinational enterprises exist. Instead a licensing contract is much less demanding in terms of acculturation. The firm has no need to learn how to deal with suppliers or potential customers. The local licensee brings in this knowledge. Similarly the "syncretic" theory would predict that a greater cultural distance rises the risk of failure for the foreign operation, which in turn makes more likely a market-based relationship. These observations lead to the following hypothesis:

H1: Cultural distance reduces the propensity of a firm to set up a wholly owned subsidiary in a foreign country rather than using licensing to exploit some technological competencies.

Learning through past experience

Although we focus on the decision concerning a single production site, the process of penetration in a foreign country is by its true nature a dynamic process (Johanson and Vahlne, 1977). Firms like human beings learn from past experiences. Firms that expand abroad are likely to acquire knowledge about foreign sites, including foreign culture, institutional characteristics, and other site-specific knowledge. This learning does not reduce the cultural distance between home and target country but certainly improves the firm experience in operating a business in a given foreign market (Johanson and Wiedersheim-Paul, 1975; Root, 1987). In turn, this reduces the costs of starting-up a new venture in the same country in future years.[2] In a slightly different perspective, knowledge of the foreign business environment reduces the risks associated with the international operation, which in turn – as predicted by the "syncretic" theory – makes the firm more willing to commit a larger amount of resources. Consequently, we can state the following hypothesis:

H2: Past business experience in a given country increases the propensity of a firm to set up a wholly owned subsidiary rather than using licensing to exploit some technological competencies in the present.

It is plausible that the experiential learning accumulated through past projects in a country depends on the form of the project. Projects that involve a stronger linkage with the local context such as the creation of a wholly owned subsidiary or a joint venture with a local partner give to the firm a much more diverse and richer experience than a licensing arrangement. This suggests the following hypothesis:

H3: Firms accumulate more valuable experiential learning from wholly owned subsidiaries and joint ventures rather than from licensing contracts.

Number of technology sources

Several studies have investigated the relationship between market structure and multinational investments (Caves, 1982; Buckley and Casson, 1976). One stylized fact seems to emerge: foreign direct investments are more widespread in less competitive markets. This is also confirmed by the findings that multinational investments are largely targeted to differentiated and segmented industries where competition is less intense (Grubaugh, 1987; Mork and Yeung, 1991). One explanation to this pattern seems very plausible: since operating a business abroad is rather costly, firms are actually more willing to embark in an investment if there are prospects of large future profits. Under tough competition a licensing agreement economizes on the setup costs of starting operating across natural and cultural boundaries.

This leads to an important consideration: the entry mode strategy cannot be analyzed in isolation from what other potential competitors do or might do. Unfortunately, little attention has been devoted to this point by scholars in the field of international business studies. A firm investing in a foreign country is concerned with the present value of the future flows of profits, which have to be larger than the entry costs. Future profits are related to potential entrants in the market. Rival firms (both local and international) might be attracted by the presence of profitable businesses and start entering the market. Obviously an entrant needs to have access to the technology in order to start the production. All else held equal, the more sources of technology there are, the easier is entry and more intense the competition. Put it differently, the presence of a well-established market for technology, where technologies can be bought and sold as any other economic good (Arora, Fosfuri and Gambardella, 1999), makes technology licensing by international investors more likely.

H4: The larger the number of sources of technological competencies the lower the propensity of a firm to set up a wholly owned subsidiary rather than using licensing to exploit its technology in a foreign market.

Testing this hypothesis involves an important qualification. As Kogut and Zander (1993) have pointed out, firms are a more efficient vehicle for transferring technologies that are complex, tacit and difficult to teach, while market-based transactions in technology are more likely to occur when technologies are more codified and easier to transfer across organizational boundaries. This means that the number of sources of technological competencies might simply be a proxy of some more fundamental attributes of technology. Accordingly, in our empirical analysis below, we control for characteristics of the technology such as complexity and codifiability to sort out the confounding effects.

METHODOLOGY

The unit of analysis of this study is an individual project undertaken into a foreign market between 1981 and 1991. Our sample includes all the largest chemical firms (in terms of their total turnover by the year 1988) which have at least one investment project during the 1980s in our database. This constitutes a set of 153 chemical firms that, by and large, are all the most important chemical firms from developed countries, accounting for overseas investment of more than $50 billion a year during the period under study.[3, 4]

Our data on chemical projects undertaken abroad come from the Chemical Age Project File (CAPF), which covers all new chemical plants (over 20000) announced all over the world during 1981-1991. In addition to its novelty, this database is also comprehensive – it covers all chemical plants constructed or under construction anywhere in the world during the time period. The database contains the name of the company that operates the plant (or the names of the partners if the project is run under a joint venture) and that of the firm that have licensed the technology. In addition, it provides information on the location (country and region), the technology used and, for a smaller number of observations, capacity and costs. For the purpose of the present study, these data allow us to identify whether, for a given project abroad, the firm that ultimately possessed the technological capability, has chosen to set up a fully owned operation or to adopt a licensing strategy.

To clarify the terminology, we shall label "wholly owned project" a plant operated by only one firm, whereas we shall use "joint venture" to identify a plant operated by more than one firm. In the latter case our database does not give us more details about the governance structure, hence joint venture might be a mixture of different cases.

In the econometric analysis below, we exploit the time dimension of the data and split the investment projects in two periods: 1981-1985 and 1986-1991. We run our regressions only on projects undertaken in the second period and use the first period observations to construct some of the independent variables (see below). This allows us to control better for other factors that affect the choice between wholly owned subsidiary and licensing, avoiding potential endogeneity problems. In most of our model specifications, we restrict our set of projects undertaken abroad to the ones belonging to a sample of 136 process technologies. These are the most important process technologies in chemicals and cover about 75% of all projects undertaken abroad. Although some bias might be introduced by restricting the sample of process technologies, the obvious advantage in terms of robustness of our results is that we can control for the nature of technology and other technology-specific sources of variation.

Variables

Mode of entry. We identify as wholly owned projects all plants abroad for which any of the firms of our sample is the exclusive owner. We classify as licensing all investment projects reporting any of the firms of our sample as the licensor of the technology. We capture this dichotomy in the entry mode through a binomial dependent variable that takes the value of 1 in case of wholly owned project and the value of 0 in case of licensing.

Table 1 reports the number of projects (either wholly owned projects and technology licensing) undertaken into foreign markets by the firms of our sample during the period under study, by region. The table shows that the non-Japanese firms in our sample were more likely to use licensing than a wholly owned project when entering the Japanese market, while the reverse is true for Western Europe and North America . The developed regions as a whole (North America, Western Europe and Japan) account for more than two thirds of all wholly owned projects set up by the firms of the sample, but only a third of total licensed projects. Further, the firms in our sample when entering foreign markets in the developed countries have a higher propensity to internalize (henceforth PI) defined as the ratio between the number of wholly owned projects and the sum of licensed and wholly owned projects. An increase in this ratio means that firms tend to prefer internal organization vis-à-vis market transactions for the exploitation of their technological competencies abroad. For developed regions the PI is close to 0.80 compared to less than 0.45 for the rest. In other words, the leading chemical firms are more likely to use wholly owned ventures vis-à-vis technology licensing for projects undertaken in developed countries than in developing countries, with Japan being somewhat of an outlier among developed countries.

Cultural distance. (CULTDIST) We measure the cultural distance between the host and the target country using the four cultural dimension classification developed by Hofstede (1980, 1991). We construct an index that captures for the cultural distance along the four dimensions. This index has been initially used by Kogut and Singh (1988) and later in many other studies of foreign entry (e.g., Barkema and Vermeulen, 1998; Hennart and Larimo, 1998; Benito and Gripsrud, 1992). For a given country-pair, the cultural distance is calculated as the arithmetic average of the deviations in the Hofstede's four dimensions, correcting for the overall variance of each of these four dimensions. Since this measure is unavailable for China, we use a dummy (DUMCHN) to account for this.

Experience. We use two separate measures of experience to capture for differences in the experiential learning accumulated through the different investment modes chosen for the foreign projects. EXPALL measures experience as the total number of projects (of whatever type) in a given country in the five years preceding the project under study. EXPFDI only counts the projects which involve some forms of direct investment in the foreign country, either wholly owned projects or projects operated jointly with local firms. Although not reported here, using different time spans for measuring experience yields similar qualitative results.

Potential licensors. (POTLIC) The number of potential licensors (i.e., sources of technological competencies) is measured by counting all firms (but the investor) that had actively licensed a given technology in the period 1981-1985. This constitutes a proxy both for the number of potential licensors in the period 1986-1991 and for the present and future market structure in the host country. However, it is plausible to posit that the effect of the presence of potential licensors is not linear. Adding an additional competitor to an already crowded market will not increase competition by much. On the other hand, there is a dramatic change in the profitability when an incumbent monopolist is threatened by an entrant, or incumbent duopolists are faced with another competitor. In other words, we expect the effect of an increase in the number of potential licensors to be initially quite strong and then progressively less important as the number of potential licensors increases (see also Bresnahan and Reiss, 1991). To capture this decreasing effect we use the logarithm of the number of potential licensors (LPOTLIC). We have also tried a quadratic term with similar qualitative results.

Control Variables

Geographic distance. (PROXIMITY) We use a dummy variable to capture the geographic proximity between home and host country. The variable takes the value of 1 when the project undertaken abroad is in a country that shares some common borders with the home country or it is located within a 100 mile range. The variable takes the value of zero otherwise. Communication costs between the foreign operation and the headquarters, which are increasing with geographic distance, would suggest a positive effect of this variable on the propensity to set up a wholly owned project.

Language. (LANGUAGE) This dummy takes the value of 1 if the home and the host country have at least one of their official languages in common and 0 otherwise. Having the same language might imply reduced communication costs between the foreign operations and the headquarters. It might also imply an easier adaptation process for the expatriates who are sent abroad. In sum, we expect this dummy to affect positively the propensity of a firm to set up a wholly owned project rather than licensing.

Firm size. (SIZE) Although our sample is biased towards large firms, we control for firm size because investments abroad require large financial and managerial resources. Small firms, which lack the resources and expertise to venture into foreign markets, might find easier to license their technology and when they grow larger they might eventually shift to a network of subsidiaries (see for instance, Ermanilli and Rao, 1993). In other studies the evidence is mixed. Gomes-Casseres (1989) finds that larger firms prefer high levels of equity ownership, whereas Contractor and Kundu (1998) find the opposite.

Market size. (GDP) The size of the foreign market can actually influence the profitability of the investment and therefore the mode of entry in the foreign country (see for instance, Gomes-Casseres, 1989; Shane, 1993; Zejan, 1990). We use the Barro-Lee database (a widely used source of country level data) to obtain information about the level of GDP in the host countries. GDP has two conflicting effects on the choice between wholly owned project and licensing. On the one hand, a small market may not be worth the effort, particularly since any learning is likely to have only limited applicability. On the other hand, a large market may also be more competitive, implying that licensing may be a more attractive strategy. Also, a larger market may imply a greater possibility of more suitable potential licensees, an important consideration for the licensing strategy, particularly for developing country markets (e.g., Contractor, 1981; Arora, 1996).

Tariffs on intermediate inputs and capital goods. (OWTI) The existence of restrictions to both capital investments and trade of inputs might reduce the profitability of a direct investment in the foreign country (Contractor, 1990; Gomes-Casseres, 1990). Although many countries take part to international trade agreements, there are still considerable differences in countries' openness towards investments and trade. To capture this difference we use the level of tariffs on capital investments and intermediate inputs, from the Barro-Lee database.

Country risk. (NORISK) The larger the level of uncertainty in the returns from the project undertaken abroad, the less willing the firm to commit resources (Kim and Hwang, 1992; Buckley and Casson, 1998). This would suggest that countries characterized by higher level of risk should attract relatively less wholly owned projects and more licensing. We use a measure of country risk developed by the International Country Risk Guide (ICRG). The ICRG compiles monthly data on a variety of political, financial and economic risk factors (see for more details Erb, Harvey and Viskanta, 1996). Our measure of risk is a weighted average of the political, financial and economic risk. For the interpretation of the sign, one should be aware that a higher value of this variable is associated with less risk in the country. In other words, we expect the variable to have a positive sign on the probability to set up a wholly owned project as expansion strategy abroad.

Core technology. (CORE) This is a dummy which takes the value of 1 when the technology is a core technology and 0 otherwise. Core technologies are defined as technologies in which the firm concentrates a large share (more than 20%) of its total investment in the home country. We expect that firms are less willing to license technologies in the core business, because of the greater danger from potential competitors.

Codifiable technology. (CODIFIABILITY) We measure the degree of codifiability of the technology using the number of patents reported for that technology at the US Patent Office in a large number of years (1976-1991). As several authors have noted (e.g., David, 1993; Arora, 1997), patents are more likely to be issued for technologies where the underlying knowledge is sufficiently codifiable. As suggested by Kogut and Zander (1993) and Arora and Gambardella (1994), codifiability of the underlying knowledge base reduces the direct costs of information exchange across firm boundaries that a licensing agreement would entail. Patent data are organized in patent classes that are typically much coarser than the level of a single chemical process. Therefore, we had to develop a set of queries for collecting the number of patents on the 136 chemical process technologies in our sample from the online US Patent Office database.[5] We have standardized this variable to take values between 0 (not codifiable) and 1 (codifiable).[6]

Complex technology. (COMPLEXITY) As defined by Kogut and Zander "complexity is the number of critical and interacting elements embraced by an entity or activity". We use the number of patents on uses, inputs, components and applications of a given technology as a measure of the complexity of the technology itself. This variable was constructed through a careful process that involved reading the patent abstracts and constructing queries to search the US Patent Office online database (see footnote 5). We have standardized this variable to take values between 0 (simple) and 1 (complex).

Degree of multinationality. (MULTI) This variable reports the number of countries in which the firm had directly invested in the period 1981-1985. This might capture for firm experience in dealing with international investments. So, we expect that the degree of multinationality has a positive effect on the probability that the project undertaken abroad is carried out through a wholly owned operation.

RESULTS

A first cut to the data

We begin to explore our main hypotheses using simple tables. Although the "syncretic" theory (Hill, Hwang and Kim, 1990; Contractor, 1990) argues that country-specific, technology-specific and firm-specific variables should all be included in a unique multivariate analysis, parametric analysis imposes untestable restrictions on functional form. The following tables, however, indicate that the results we obtain from the formal regressions are robust to such functional form restrictions, and our logit analysis with multiple controls below, broadly confirms the results of the simple analysis carried out here. We present three tables capturing respectively the effects of cultural distance, country experience and the presence of multiple sources of technological competencies on the choice between wholly owned project and technology licensing.

The first table (Table 2) shows how larger cultural distance between home and host country makes less likely that a foreign project is carried out through a wholly owned operation rather than licensing. We have constructed five classes that are intended to capture for different levels of cultural distance. Classes broadly correspond to quintiles. Countries which are very similar in the Hofstede's four dimensions, like United States and Australia or Germany and Austria, enter in the first class labeled "Same culture". Countries which are very different in all four dimensions, like Japan and Morocco or Sweden and Japan, are in the "Opposite cultures" class. In the construction of the classes we have also experimented different groupings with the results being robust to variations in the construction of the cultural distance classes.

In this table we used the projects (both wholly owned projects and licensing) undertaken abroad in the whole period covered by our data set (1981-1991) for sixty countries for which we could measure cultural distance. This amounts to 3836 projects with a mean cultural distance of 1.601 and an average PI ("propensity to internalize") of 0.673. The last column of the table shows clearly that the PI decreases as the cultural distance between home and host country increases, indicating that increasing cultural distance favors licensing.

Table 3 studies the effect of country experience on the decision between wholly owned project and technology licensing. We divide the observations in three groups. The first group includes all projects for which the firm has got no experience in the country in the preceding five years. The second group contains all projects for which the investor has accumulated some 'general' country experience, be it from licensing, joint ventures, wholly owned projects. The last group only considers the projects for which the firm has accumulated a more 'qualified' experiential learning through prior investments entailing greater involvement with the foreign country business environment such as joint ventures or wholly owned projects.

The table reports projects (both wholly owned projects and licensing) undertaken abroad during the period 1986-1991. This is the time dimension we shall exploit in the logit regressions below. There are 2443 of such projects abroad in this period by the sample firms. The average PI is 0.61. Notice that the average PI is only 0.47 for projects in which the investor has not previous experience in the country, and rises to 0.68 for projects in which the investor has got some 'general' experience, and further to 0.83 when the firm has previously invested in a wholly owned project or joint venture. The table suggests that country-specific experience makes future investments through wholly owned projects rather then licensing more likely, and this effect is more pronounced when the experiential learning comes from prior projects entailing greater involvement with the foreign country business environment. Moreover, this pattern seems to be persistent across different geographic areas.

Table 4 studies the influence of the number of sources of technological competencies in a given process technology on the choice between wholly owned project and technology licensing. We construct six different classes ranging from no potential licensors to many. Although the construction of the classes is somewhat arbitrary, here too, experiments with different groupings show no significant changes in the results. The table reports all projects (wholly owned projects and licensing) undertaken abroad during the period 1986-91 by the firms of our sample. As expected, the PI is the largest when there are no potential licensors in a given process technology. The PI decreases as we move to classes with a larger number of potential licensors. Note also that the last column shows an increase in the PI. This points to the role of other factors, and the need to control for those factors through a multivariate regression.

Logit analysis

Table 5 reports means, standard deviations and correlations of our independent variables. The results of the binomial logit regressions are presented in Table 6. A positive coefficient means that the independent variable tends to increase the probability that a wholly owned project is set up, whereas a negative coefficient implies the opposite. We estimate four different model specifications. Model 1 and 2 only include the explanatory variables whose sign was predicted by the hypotheses we have worked out above. We used all projects undertaken abroad by the firms of our sample during the period 1986-1991 in the sixty countries for which the measure of cultural distance was available. For China, since the measure of cultural distance was missing we have used a dummy: DUMCHN. Model 1 and 2 differ in the definition of country experience we have adopted. In the former, EXPALL measures experience as the number of projects (of whatever type) in a given country in the five years preceding the project under consideration. In the latter, EXPFDI only counts joint ventures and wholly owned projects. Model 3 and 4 still maintain the above mentioned difference in the measure of country experience, and add several control variables. In particular, as suggested by Kogut and Zander (1993), we have included controls for the nature of the technology: CODIFIABILITY and COMPLEXITY. For this reason, we had to focus on a sub-set of 136 process technologies, for which we have been able to compute these two measures. We use other country-, firm- and technology-specific controls, to isolate the effect of our main explanatory variables from spurious sources of variation. We also estimated a fixed-effects logit specification controlling for firm fixed effects. The results, not reported here and available from the authors upon request, are qualitatively similar to the ones shown in Table 6.

Hypothesis 1 predicts that larger cultural distance increases the preference for licensing agreements. The parameter estimate of the effect of cultural distance (CULTDIST) is negative and highly significant in all specifications ($p < 0.001$ in all models). This supports Hypothesis 1. Notice also that DUMCHN is also negative and significant, implying that on average wholly owned projects are less likely to be set up in China. Interestingly enough, this effect remains after we control for other country characteristics like GDP, country risk, and openness to foreign direct investment (see model 3 and 4).

Hypothesis 2 predicts that firms learn from previous experience and this learning contributes to reduce the cost of a wholly owned project in a foreign country. Put differently, a firm is more willing to commit resources when it has previous experience in a given country. Whatever measure of experiential learning we use (EXPALL or EXPFDI) we find that the coefficient of the variable is positive and highly significant ($p < 0.001$), which confirms the prediction of Hypothesis 2. Further, the estimated coefficient of EXPFDI is larger than that of EXPALL, with the marginal effect calculated at the means of the regressors being twice as large (0.015 versus 0.007 in models 3 and 4 respectively). In addition, models 2 and 4 fit the data better than do models 1 and 3 respectively. This supports Hypothesis 3.

Hypothesis 4 suggests that a larger number of potential licensors makes more difficult to recover the cost of the investment since entry by competitors is more likely (there is no exclusivity in the technological competencies). In turn, this implies that when the number of potential licensors is large, a firm prefers to use technology licensing rather than setting up a wholly owned project. Consistent with Hypotheses 4, the coefficient of the logarithm of the number of potential licensors (LPOTLIC) is negative and highly significant ($p < 0.001$). Either using a quadratic term or simply using the variable POTLIC give a similar result in terms of the predicted effect of the number of potential licensors.

Finally, in model 3 and 4 we have controlled for many different sources of heterogeneity in our data. In particular, we have tried to control to our best for the nature of technology, which has been identified by Kogut and Zander (1993) as one of the main determinants of the choice between licensing and wholly owned subsidiary. In addition, as discussed above, this allows us to be much more confident about the true effect of LPOTLIC. Indeed, both for CODIFIABILITY and for COMPLEXITY we obtain the expected sign and a high level of significance. Similar to Kogut and Zander (1993), our results suggest that technologies with a greater tacit component and those that are complex are more difficult to transfer through market-based transactions.

The signs of the other variables are reasonable. The fact that home and host country are located close one to the other and that they have the same language increases the odds that the project is carried out through wholly owned operation rather than licensing. The total turnover of the firm (SIZE) does not have any significant effect, and neither does the international experience of the investor (MULTI), whereas the results indicate that firms are less likely to license core technologies. GDP has a small negative effect on the probability of observing a wholly owned project, indicating that the large market benefits of the value of learning does not fully balance the availability of suitable licensees and the increased toughness of competition. Instead, economic, financial and political risks and barriers on capital investments and intermediate goods, increase the probability of licensing.

Multinomial logit and ordered logit

As an extension to the analysis carried out so far, we also perform multinomial logit and ordered logit regressions (see Greene, 1993). Hitherto, joint ventures were excluded from our analysis. However, our database reports if a plant is operated by more than one firm. We use this information to identify a joint venture as an entry mode separate from licensing and wholly owned project. We have therefore three possible entry modal choices: wholly owned project (M=1), joint venture (M=2) and technology licensing (M=3). We first estimate a multinomial logit specification where we use all control variables described above. We again differentiate between the two types of experiential learning: EXPALL and EXPFDI (see model 5 and 6).

It seems natural to rank the three alternatives in terms of the implicit governance structures as lying on a continuum between a hierarchy and a market mechanism (e.g., Hill, Hwang and Kim, 1990; Contractor and Kundu, 1998). This suggests that an ordered logit regression might be appropriate, and we use an ordered logit to estimate model 7 and 8, which again differ only in how we measure country experience. We code the three modes, wholly owned project, joint venture, and licensing as 1, 2, and 3 respectively, with a higher rank indicating an entry mode closer to a market. For the interpretation of the results, recall that in the multinomial logit, a posit sign means that the variable increases the likelihood of the entry mode under consideration compared to the reference mode (wholly owned project), while in the ordered logit a positive sign implies that the variable increases the probability of entry modes of higher rank – i.e., of modes closer to markets and farther from hierarchies.

Overall, the results are consistent with those in Table 6, with joint ventures appearing as an intermediate case between wholly owned project and licensing. There are, however, a couple of anomalous results. First, in the multinomial logit regressions, country experience – either EXPALL or EXPFDI, reduces the odds of licensing, but increases those of a joint venture vis-à-vis wholly owned project. This might suggest that experiential learning is more important when the investor has to share the control of the foreign project with a local partner rather than when she has full control over the foreign operation. Simply put, learning seems to be a crucial determinant for the likely success of cooperative ventures, alliances and strategic coordination with local partners. Second, all technology-specific variables do not affect the choice between a wholly owned project and a joint venture, but do affect the choice between these and licensing. An interesting explanation is that there is no qualitative difference in the knowledge transferred through wholly owned subsidiaries and joint ventures, and that joint ventures may be used as well to transfer knowledge that is organizationally embedded and difficult to transfer by licensing (Kogut, 1988). Finally, the results of the ordered logit specification go in the same direction as our results in Table 6, implying that ranking the three alternatives by their implied governance structure is sensible.

CONCLUSION

This study offers some fresh evidence on a crucial strategic decision by firms involved in global competition: when is licensing better than a wholly owned subsidiary for exploiting technological competencies abroad? This paper adds to the somewhat sparse empirical literature on this topic (Contractor, 1984; Davidson and McFetridge, 1984; Contractor and Kundu, 1998). We use a new database that covers all chemical plants constructed or under construction worldwide during the 1980s. We develop a sample of the overseas investments and licenses of the largest 153 chemical firms in the world. Although confined to one industry, our data set is rich and comprehensive. In addition, we believe that the results from the chemical industry should provide insight into other scale and technology intensive industries. Another strength of our analysis comes from the large number of firms' nationality included in our sample. This is not typically the case in many other studies in the field of international business, which often rely on data from a single country. By focusing on an industry, we can better control for differences in technology characteristics, such as codifiability and complexity, which is much more difficult in cross-industry studies. Finally, another important contribution of this paper is the analysis of the role of competition, especially in the market for technology, in conditioning the choice of the mode of entry.

We find that cultural barriers are an important limitation to the commitment of resources. Firms prefer to exploit their technological competencies through licensing when the target country is culturally far away from the home country. Geographic distance and difference in language favor the use of licensing as a strategy for expanding abroad as well, suggesting that communication, control and coordination are important at the international level, and that firms move to distant countries gradually and only after having established a presence in more proximate countries (Johanson and Vahlne, 1977).

Our results also support the idea that learning plays a crucial role in the design of internationalization strategies. We find that prior experience in the host country increases the odds that the project is carried out through a wholly owned operation rather than licensing. Results also confirm that this experience is more valuable when it comes from prior projects which entail a greater degree of involvement with the foreign business environment such as joint ventures or wholly owned subsidiaries.

Our results imply that firms need to explore both licensing and wholly owned operation as means of exploiting their technological capabilities to full effect. In so doing, they must take into account factors, such as cultural distance and the nature of technology, that affect the cost of technology transfer through contract based mechanisms such as licensing. Our results also shed light on a research question that has been little explored empirically. Although it is widely accepted that a firm's expansion strategy cannot be analyzed in isolation, empirical studies on entry modes have typically ignored this point. We find that the presence of other sources of technological competencies favors the use of licensing vis-à-vis wholly owned projects. This is consistent with the idea that when the technological competencies the firm possesses are not unique, entry in the market is more likely. In turn, this implies that a firm might instead opt for a licensing strategy, which is less demanding in terms of resources and commitment.

As a byproduct, this paper confirms the finding in Kogut and Zander (1993), namely that the nature of technology plays a critical role in the choice of the internationalization strategy of the technology holder. Indeed, we find that codifiability of technology encourages licensing. By contrast, technologies with a greater tacit component and those that are more complex tend to be transferred through internal rather than market-based transactions.

NOTES

1. The chemical industry, which we study here, has been a global industry for many years. In 1994 the book value of foreign direct investments in the US was $61.3 billion, compared to $51.6 billion of US investment in foreign chemical companies. A great deal of international trade consists of intra-firm transactions of such companies. In 1994 US chemical company parents exports amounted to $51.5 billion, of which over two thirds went to their foreign affiliates. Likewise, 56% of the US chemical imports were channeled through the US affiliates of foreign companies. International technology flows, which are often related to capital, are also significant. In 1993 US companies received $2.3 billion in royalties and licensing fees and paid $1.2 billion. (All figures taken from the Chemical Manufacturing Association, 1994).

2. It is worth noting that often discussions of learning tend to blend the information gathering and adaptation. Put differently, a firm may learn about a country's institutions and practices and decide not to proceed any further. This notion is related to the recently developed literature on the theory of "real options". (See Dixit and Pindyk, 1994). According to this theory, firms may treat their initial forays into a country as an opportunity to learn in order to lead to a better informed decision on whether to expand further in that country. These considerations are not directly relevant for our study because we examine the choice of the mode of the entry, conditional on the firm having decided to enter.

3. The sample includes 68 American or Canadian firms, 32 Japanese and 53 West European firms. Also, notice that some of these firms were not actively investing or licensing abroad during the period under study.

4. This estimate is computed using the average cost of investment in a given chemical project, which is about (current) $100 million. Counting both direct investments, joint-ventures and licensing, our data set reports a little more than 5000 projects abroad for the firms of the sample during the period under study.

5. We selected all relevant patents using a keyword search with the process as keyword. From these, we selected and read the full abstracts of patents that exactly fit our criterion. The patent classes (and sub-classes) into which these patents were classified were examined to ensure that the invention was in fact a process technology invention. These sub-classes of the US patent classification system were used along with the process name as the basis for Boolean queries of the US patent database to generate the final set of patents, one set for each technology. (The details of the Boolean queries are available upon request.) The titles (and some abstracts selected at random) of the patents in the final sample for each technology were examined to ensure that the final sample did not contain irrelevant patents.

6. Both the variable CODIFIABILITY and the variable COMPLEXITY have been standardized according with the following formula: $(x - x_{min})/(x_{max} - x_{min})$, where x is the original variable and x_{max} and x_{min} the maximum and minimum values it takes across all 136 technologies.

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TABLE 1: GEOGRAPHIC DISTRIBUTION OF THE PROJECTS UNDERTAKEN ABROAD BY THE FIRMS OF THE SAMPLE

Period	Entry Mode	NA	WE	JAP	First World	AF, ME and EE	SA	FE	Third World	Total
1981-1985	WOP	396	456	38	890	51	152	174	377	1267
	LIC	71	141	54	266	235	51	186	472	738
1986-1991	WOP	487	605	46	1138	50	121	251	422	1560
	LIC	74	161	53	288	235	110	327	672	960
1981-1991	WOP +LIC	1028	1363	191	2582	571	434	938	1943	4525

Note: WOP = Wholly Owned Project; LIC = Licensed Project; NA = North America, WE = Western Europe, JAP = Japan, AF = Africa, ME = Middle East, EE = Eastern Europe, FE = Far East.

TABLE 2: CULTURAL DISTANCE AND THE CHOICE BETWEEN WHOLLY OWNED PROJECT AND TECHNOLOGY LICENSING

How different are home and host country cultures?	CULTDIFF	Number of projects	% of total projects	PI
Same culture	[0, 0.25)	766	20	0.838
Close cultures	[0.25, 1)	713	19	0.780
Not very close cultures	[1, 2)	918	24	0.655
Different cultures	[2, 3)	775	20	0.555
Opposite cultures	[3, ∞)	664	17	0.491
	1.601	3836	100	0.673

TABLE 3: COUNTRY EXPERIENCE AND THE CHOICE BETWEEN WHOLLY OWNED PROJECT AND TECHNOLOGY LICENSING

Geographic Area	PI: no country experience	N. of projects (86-91)	PI: 'general' country experience	N. of projects (86-91)	PI: 'qualified' country experience	N. of projects (86-91)
North America	0.679	53	0.886	502	0.909	485
Western Europe	0.720	229	0.810	508	0.896	441
Asia and Japan	0.403	258	0.432	396	0.633	237
Rest of the World	0.297	265	0.336	232	0.618	110
World	0.471	805	0.675	1638	0.828	1273

TABLE 4: POTENTIAL LICENSORS AND THE CHOICE BETWEEN WHOLLY OWNED PROJECT AND TECHNOLOGY LICENSING

	Number of Potential Licensors (POTLIC)						
	0	*1-2*	*3-5*	*6-10*	*11-15*	*>15*	*All*
PI	0.829	0.719	0.651	0.527	0.394	0.507	0.607
# of projects	485	352	404	385	452	365	2443
% of projects	20	14	17	16	18	15	100

TABLE 6:

LOGIT REGRESSIONS: WHOLLY OWNED PROJECT (=1) VERSUS TECHNOLOGY LICENSING (=0)

Variables	model 1	model 2	Model 3	model 4
Constant	2.544^{***}	2.371^{***}	-1.102^{+}	-1.083^{+}
	(0.230)	(0.229)	(0.601)	(0.604)
CULTDIST	-0.352^{***}	-0.298^{***}	-0.227^{***}	-0.197^{***}
	(0.043)	(0.043)	(0.060)	(0.060)
DUMCHN	-4.165^{***}	-3.869^{***}	-4.113^{***}	-3.794^{***}
	(0.476)	(0.479)	(0.744)	(0.747)
EXPALL	0.055^{***}		0.034^{***}	
	(0.009)		(0.011)	
EXPFDI		0.110^{***}		0.082^{***}
		(0.014)		(0.015)
LPOTLIC	-0.536^{***}	-0.530^{***}	-0.425^{***}	-0.429^{***}
	(0.060)	(0.061)	(0.105)	(0.106)
PROXIMITY			1.021^{***}	0.978^{***}
			(0.211)	(0.212)
LANGUAGE			0.388^{+}	0.336
			(0.205)	(0.206)
GDP			-0.000^{*}	-0.000^{***}
			(0.000)	(0.000)
OWTI			-0.756^{**}	-0.679^{*}
			(0.274)	(0.273)
NORISK			0.027^{***}	0.027^{***}
			(0.005)	(0.005)
SIZE			0.000	0.000
			(0.000)	(0.000)
MULTI			0.010	-0.002
			(0.017)	(0.017)
CORE			0.333^{*}	0.353^{*}
			(0.160)	(0.162)
CODIFIABILITY			-1.112^{**}	-1.112^{**}
			(0.419)	(0.423)
COMPLEXITY			1.928^{***}	1.985^{***}
			(0.551)	(0.562)
Number of obs.	2241	2241	1388	1388
Log Likelihood	-1155.65	-1126.55	-731.11	-716.33
Chi-squared	625.55 (4)	683.76 (4)	455.03 (14)	484.59 (14)
Share of ones	0.637	0.637	0.535	0.535
Correctly classified	73.7%	75.6%	74.8%	76.2%

Notes:

1. Numbers in parentheses are standard deviations.
2. Regressions in model 1 and 2 include the following sector dummies: Air Separation, Fertilizers, Gas Handling, Inorganic Chemicals, Industrial Gasses, Inorganic Chemicals, Oil Refining, Plastics, Petrochemicals, Textile and Fibers.
3. $^{+}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

TABLE 7:
MULTINOMIAL LOGIT AND ORDERED LOGIT

Variables	Model 5 JV (M=2)	Model 5 LIC (M=3)	Model 6 JV (M=2)	Model 6 LIC (M=3)	Model 7 Ordered Logit	Model 8 Ordered Logit
Constant	0.078	1.355*	0.055	1.348*		
	(0.758)	(0.598)	(0.759)	(0.601)		
CULTDIST	0.342***	0.230***	0.331***	0.200***	0.196***	0.181***
	(0.075)	(0.060)	(0.074)	(0.060)	(0.048)	(0.048)
DUMCHN	4.636***	3.979***	4.689***	3.645***	2.173***	1.952***
	(0.799)	(0.741)	(0.803)	(0.743)	(0.287)	(0.289)
EXPALL	0.040**	-0.038***			-0.025***	
	(0.012)	(0.011)			(0.008)	
EXPFDI			0.044**	-0.097***		-0.060***
			(0.014)	(0.016)		(0.010)
LPOTLIC	0.121	0.461***	0.121	0.462***	0.401***	0.395***
	(0.130)	(0.104)	(0.129)	(0.105)	(0.084)	(0.085)
PROXIMITY	-1.133***	-0.918***	-1.137***	-0.867***	-0.833***	-0.805***
	(0.304)	(0.203)	(0.304)	(0.205)	(0.173)	(0.173)
LANGUAGE	-0.935**	-0.451*	-0.961**	-0.419*	-0.560**	-0.506**
	(0.312)	(0.208)	(0.314)	(0.210)	(0.182)	(0.182)
GDP	-0.000**	0.000*	-0.000**	0.000*	0.000^{+}	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OWTI	1.274***	0.837***	1.297***	0.737**	0.745***	0.645***
	(0.327)	(0.274)	(0.328)	(0.274)	(0.203)	(0.203)
NORISK	-0.027***	-0.029***	-0.027***	-0.029***	-0.025***	-0.025***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.004)	(0.004)
SIZE	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MULTI	0.011	-0.013	0.014	0.002	-0.014	-0.000
	(0.021)	(0.016)	(0.021)	(0.016)	(0.013)	(0.013)
CORE	-0.186	-0.354*	-0.197	-0.384*	-0.318*	-0.343**
	(0.207)	(0.157)	(0.207)	(0.159)	(0.130)	(0.131)
CODIFIABILITY	0.543	1.017*	0.583	1.013*	0.737*	0.720*
	(0.529)	(0.413)	(0.529)	(0.416)	(0.338)	(0.339)
COMPLEXITY	-0.671	-2.068***	-0.676	-2.120***	-1.901***	-1.963***
	(0.719)	(0.546)	(0.721)	(0.554)	(0.456)	(0.462)
Number of obs.	1636		1636		1636	1636
Log Likelihood	-1347.94		-1325.57		-1412.81	-1397.53
Chi-squared	613.45 (28)		658.21 (28)		484.72 (14)	514.28 (14)
Share of M=2	0.152		0.152		0.152	0.152
Share of M=3	0.394		0.394		0.394	0.394

Notes:

1. In model 5 and 6, M=1 is the comparison group (wholly owned project). In models 7 and 8, intercepts 1 and 2 are respectively -1.701 (0.491), -0.9042 (0.489) and -1.763 (0.492), -0.952 (0.490).
2. Numbers in parentheses are standard deviations.
3. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE 5:
MEANS, STANDARD DEVIATIONS, AND CORRELATIONS BETWEEN INDEPENDENT VARIABLES

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CULTDIST	1.673	0.499	1.00														
2. DUMCHN	0.066	0.248	-0.32	1.00													
3. POTLIC	10.380	6.000	0.07	0.01	1.00												
4. EXPALL	5.960	11.47	-0.33	-0.08	-0.07	1.00											
5. EXPFDI	4.865	10.34	-0.33	-0.12	-0.07	0.99	1.00										
6. PROXIMITY	0.176	0.381	-0.22	0.03	-0.01	-0.05	-0.04	1.00									
7. LANGUAGE	0.232	0.422	-0.46	-0.15	-0.06	0.37	0.38	0.22	1.00								
8. GDP	971.1	1272	-0.35	0.20	-0.07	0.58	0.56	-0.16	0.12	1.00							
9. OWTI	0.145	0.276	0.07	0.10	0.08	-0.15	-0.17	-0.14	0.06	-0.12	1.00						
10. NORISK	74.80	16.29	-0.36	-0.07	-0.06	0.35	0.36	0.19	0.29	0.43	-0.44	1.00					
11. SIZE	8414	6833	-0.10	-0.06	-0.01	0.20	0.21	-0.06	0.04	0.05	0.03	-0.03	1.00				
12. MULTI	8.895	5.640	-0.12	-0.08	-0.05	0.38	0.38	-0.09	0.208	0.06	-0.05	0.04	0.66	1.00			
13. CORE	0.251	0.434	-0.01	-0.04	0.21	-0.02	-0.02	0.09	0.03	0.01	-0.06	0.07	-0.22	-0.10	1.00		
14. CODIFIABILITY	0.707	0.166	-0.05	-0.01	0.13	0.02	0.01	0.01	-0.02	0.02	-0.10	0.09	-0.15	-0.02	0.15	1.00	
15. COMPLEXITY	0.605	0.123	0.05	-0.05	0.18	-0.09	-0.10	0.04	-0.08	0.01	0.02	0.02	-0.11	-0.11	0.24	0.25	1.00

Note: Number of observations = 1388.